VITAL CAPACITY OF THE LUNGS

IN

HEALTH AND DISEASE,

VACUUM-PNEUMATIC SPIROMETER.

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Vital Capacity of the Lungs in Health and Disease—Vacuum-Pneumatic Spirometer.

The instruments for measuring the vital capacity of the chest have been designed to measure the total amount of air expelled from the chest by the deepest respiration following upon the deepest inspiration.

The instrument now described acts in a reverse manner, namely: to determine the amount of air inspired into the lungs after the deepest or fullest expiration. Our most important knowledge of Spirometry was derived from Dr. Hutchinson's exhaustive paper in the Medico-Chirurgical Transactions of 1846.

The instrument designed by Hutchinson consisted of a mouth-piece and tube, communicating with a gasometer of registered and graduated capacity, into which the patient breathed.

Mr. Towne has, of late years, invented a convenient and accurate spirometer which works on the principle of the anemometer.

The advantage of this instrument is its portability.

As is well known, the *anemometer* is a contrivance used by the meteorologist for indicating the rate or velocity and direction of the wind.

Dr. Waldenburg has described a spirometer, identical in principle with Hutchinson's, but more elaborate and capable of being employed for the purpose of inhalation of compressed or rarified air.

The chief results of Dr. Hutchinson's labors may be thus summarized.

The vital capacity of the lungs varies according to height, weight, age and disease.

1st. *Height.* There is an increase of 8 cubic inches in vital capacity for every inch in height, between 5 feet and 6 feet. Thus the vital capacity of a healthy person at 5 feet to 5 feet 1 inch being 174 cubic inches; at 5 feet 4

inches it would be 174 cubic inches + 32 = 206 cubic inches; at 5 feet 8 inches, 238 cubic inches, etc.

2d. *Weight.* Excess in body-weight is associated with diminished capacity in the proportion of about 1 cubic inch per pound excess.

3d. *Age.* from 30 to 60 years the vital capacity decreases nearly 1 and 1½ per year.

4th. *Disease.* The spirometer furnishes a very accurate standard of health, or of the extent of disease as regards the chest, the vital capacity in lung diseases diminishing from 10 to 70 per cent.

Whenever the quantity of air is 16 per cent deficient there is reason to suspect some local affection of the chest.

Dr. Graham Balfour has followed up these investigations of Dr. Hutchinson on the chest. Dr. Balfour has especially examined how far a capacity, under the average, may be taken as an indication either of a tendency to pulmonary disease, or of a feeble constitution, rendering such men liable to a higher rate of mortality than that to which men of or above the average are subject. He found that the loss to the British army by consumption was much greater among the men having a "*vital capacity*" *under the average*, than amongst men of *average capacity*, or above it; and although the proportion of deaths did not differ materially amongst those three classes, yet the invalidity was *four times* as high among men *under the average* as among others.

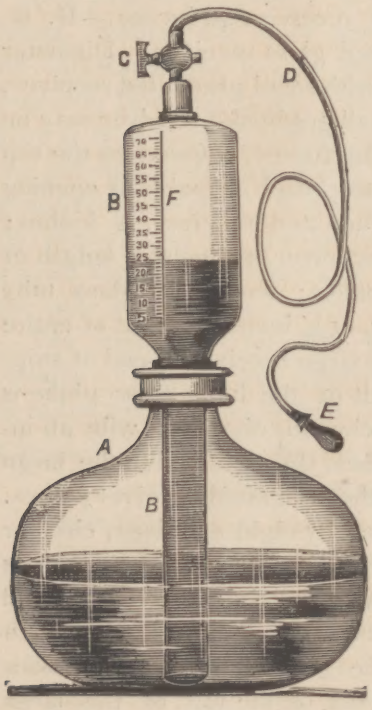
A "*vital capacity*" below the average may therefore be considered as indicating a generally feeble organization, less capable of resisting the deteriorating influences to which a soldier is exposed.—*Contributions to the Study of Spirometry, Med.-Chir. Transactions*, vol. xlviii.

Such functional incapacity is further indicated by the "*breathing being shorter*, with less breath motion." The *expiration* is quick and feeble; and there is a minimum quantity of air taken in by ordinary *inspiration*. Such lessened respiration tends of itself to induce accumulation

of mucus in the air cells, and thereby to set up inflammation. Everything which tends to impede or to interrupt or obstruct the regular, complete and constant performance of the respiratory act has a most prejudicial effect upon the lungs (especially of "growing lads"), favoring accumulation of growing material in the air cells, which may eventually degenerate and form a cheesy mass, in all respects resembling tubercle.

Life not only depends on *breathing*, but the energy and the vigor of life are in a great measure ruled by the capacity and the free play of the breathing organs.—(*Sibson.*)

During the past eighteen years I have employed the following apparatus as an important aid in the diagnosis of phthisis pulmonalis and other acute and chronic diseases of the pleura and lungs.



ENGRAVING NO. 1.

VACUUM-PNEUMATIC SPIROMETER.

A. Large glass receiver containing liquid—*pure or medicated water.*

B B. Glass tube and small graduated receiver.

C. Brass stop-cock, to entrance of graduated glass receiver.

D. Flexible tube communicating with graduated receiver B.

E. Mouth-piece communicating with flexible tube.

F. Graduated line indicating the capacity of the receiver in cubic inches.

The instrument has also proved useful in my hands for the determination of the vital capacity of the lungs as influenced by *age*, *weight*, *stature*, development and growth of *the skeleton; the growth of the muscles in relation to the bones*; *the progressive increase or decrease of the muscular force with advancing years, and the effects of preceding attacks of pleuritis, pneumonitis, pneumo-thorax, hydro-pneumo-thorax, bronchitis, asthma, emphysema and traumatic injuries of the lungs.*

The *vacuum-pneumatic spirometer* consists of a large glass globe or receiver. This receiver should be furnished with water to the amount of at least half its capacity. It is best to dissolve about one ounce of the permanganate of potassium in the water so as to remove by oxidation all deleterious organic matters which at any time might be absorbed. Diameter of large glass receiver, 15 inches; circumference of largest part of large glass receiver, 48 inches.—B. B. Glass tube and small graduated glass receiver. Diameter of large glass tube connected with small graduated receiver, 1¾ inches. The tube and small graduated receiver may be compared to a large displacement funnel, covered on the top by a brass cap and tube with stop-cock, capable of opening and closing. Diameter of graduated receiver, 6 inches; circumference of graduated receiver, 20 inches; length of graduated receiver, 12½ inches; length of glass tube attached to graduated receiver, 11¾ inches; height of entire apparatus from the base of the large receiver to end of stop-cock, 30 inches. The summit of the large glass globe is covered by a brass cap, 4 inches in diameter, with an internal opening of about 2 inches, through which the large glass tube or prolongation of the graduated receiver passes. The brass cap is also perforated by eight openings, circular and about 7-10 of an inch each in diameter. These openings allow free communication between the external air and that contained in the large receiver above the liquid which it contains. The tube of the graduated receiver passes through the brass cap or support on the top of the large receiver and reaches to within about 2 inches of the bot-

tom of the liquid. From this arrangement if air be blown through the flexible tube E, it will pass out of the receiver and tube, and bubble through the liquid and escape through the brass cap. The base or lower portion of the graduated receiver is supported by the brass cap, covering the neck of the large receiver. F, graduated lines, indicating the capacity of the receiver in cubic inches.

The o mark is at the lower extremity of the large glass tube or funnel-like prolongation of the graduated receiver, and the graduation proceeds regularly upwards to 240 cubic inches.

The graduated portion of the receiver holds 240 (two hundred and forty) cubic inches, or about 3952.2 cubic centimetres (or about 128 fluid ounces = one gallon).

Mode of Using the Vacuum-Pneumatic Spirometer.

The patient is directed to expell all the air out of the lungs, bending the body gently and steadily forward, as he expires, so as to aid the expulsion of all the air, if possible, from the lungs. The mouth-piece of the flexible tube is then placed between the lips and firmly held, whilst the patient inflates his lungs from the air confined in the graduated receiver. A partial vacuum is thus formed and the pressure of the atmosphere, about 15 pounds to the square inch, forces the water in the large receiver into the the tube and small receiver.

The amount of air thus inspired corresponds to the column of liquid which rises in the graduated receiver, and is indicated in cubic inches.

General Results of Investigations on the Vital Capacity of the Lungs in Healthy and Diseased Individuals, as Shown by the Indications of the Vacuum-Pneumatic Spirometer.

1. The accuracy of the conclusions of Dr. Hutchinson as to the relation of height, weight, age and disease to the vital capacity of the lungs has been confirmed by over 1000 experiments. The general results of the investigations of Dr. Balfour have also been confirmed.

2. In cases of incipient tuberculosis, or in the early stages of this disease, the cubic vital capacity of the lungs, irrespective of the height, or weight, or age of the adult patient (male), does not exceed on an average 130 cubic inches.

3. In advanced stages of phthisis pulmonalis the vital capacity of the lungs in adult males ranges from 60 to 120 cubic inches.

4. No correct estimate can be made of the cubic capacity of the female lungs, unless the corsets and all bandages be removed from the thorax and abdomen. Similar decrease in vital capacity of the lungs is noticed in the female suffering with phthisis pulmonalis.

5. The vital capacity of the lungs is diminished in chronic bronchitis and in pleuritis. In the latter disease the diminution of vital capacity in the lungs will correspond with the amount of liquid effused into one or both pleural cavities.

6. The vital capacity of the lungs is diminished in emphysema; in asthma during the paroxysm when the disease is spasmodic; in permanent asthmatic conditions of the lungs; and to a limited extent in chronic bronchitis.

7. Certain cases of general paralysis and loco-motor ataxia are attended with diminution of the vital capacity of the lungs, without structural alteration or the deposit of tubercles in these organs, such diminution being due to the loss of muscular power in the thoracic walls.

8. If the liquid contained in the large glass receiver be medicated with carbolic acid, iodine, petroleum or other volatile substances, beneficial effects may result from the use of the vacuum-pneumatic spirometer.

9. The daily inflation of the lungs, by the use of the vacuum-pneumatic spirometer, has proved beneficial in some cases by enlarging the capacity of the air cells. We have the means of observing accurately the changes in the capacity of the lungs of each individual under treatment.

10. The use of the vacuum-pneumatic spirometer gives precision to diagnosis and accuracy to prognosis.